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(54) [Title of Invention] Pneumatic radial tire

(57) [Abstract]

[Objective] To provide a pneumatic tire which has all of the good uniformity, excellent cornering property and high speed durability.

[Constitution]

The pneumatic radial tire is characterized as follows.

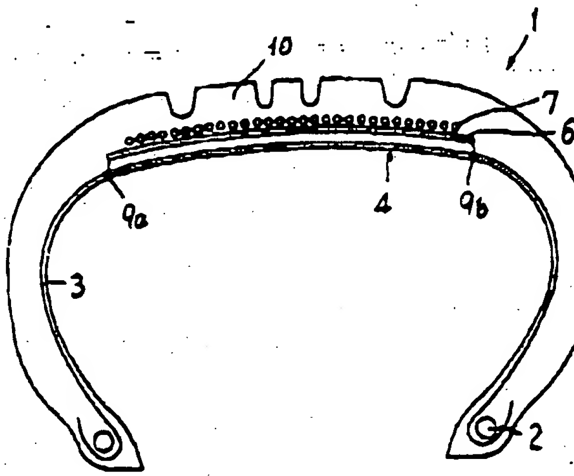
At the outer periphery of the crown section 4 of the carcass 3 which forms a toroid shape mounted between a pair of bead cores 2, the slanted belt layer 6, the belt layer 7 in the circumferential direction and the tread 10 are positioned in sequence, and

the slanted belt layer 6 is formed by having the belt body 8 made by covering one or a plural number of cords with rubber placed continuously in a zigzag form in the direction of tire circumference 5 and also by positioning the bending section of the belt body of this zigzag positioning at the end positions 9a, 9b of the width direction of the slanted belt layer 6, and

the cord of the slanted belt layer is the PEN cord having a double twist structure, this cord having a twist factor Nt which is in the range of 0.10 ~ 0.50 and the tangent loss

tan δ which is in the range of below 0.3 under the prescribed condition, and the cord diameter is in the range of below 0.85 mm and

the belt layer 7 in the circumferential direction consists of one layer and it is positioned on the slanted belt layer 6 and the cord is wound in the spiral shape to arrange substantially in parallel to the tire's equatorial plane.



[Claims of the Patent]

[Claim 1] Pneumatic radial tire which is characterized by that,

in the pneumatic radial tire which is constructed by positioning in sequence the slanted belt layer, the belt layer in the circumferential direction and the tread at the outer periphery of the crown section of the carcass which forms a toroid shape mounted between at least a pair of bead cores,

the slanted belt layer is formed by having the belt body made by covering one or a plural number of cords with rubber placed continuously in a zigzag form in the direction of tire circumference and also by positioning the bending section of the belt body of this zigzag positioning at the end position of the width direction of the slanted belt layer, and

the cord of the slanted belt layer is the organic fiber cord consisting of poly ethylene naphthalate having double twisting structure and, if the twist number of this cord is denoted by T (times/ 10 cm), the total denier by D_T, and the specific gravity by ρ, the factor N_t which is expressed by the equation : $N_t = T \times (0.139 \times D_T /2 \times 1/ \rho)^{1/2} \times 10^{-3}$ is in the range of 0.10 ~ 0.50 and the tangent loss tan δ is in the range of below 0.3 under the condition of initial

tension 1 kgf/ end, strain amplitude 0.1 %, frequency 20 Hz and atmosphere temperature 25 deg C and the cord diameter is in the range of below 0.85 mm;

the belt layer in the circumferential direction consists of at least one layer and it is positioned on the slanted belt layer and the cord is wound in the spiral shape to arrange substantially in parallel to the tire's equatorial plane.

[Claim 2] The pneumatic radial tire described in Claim 1 in which, when the belt shaped body covers the whole circumference of tire for the prescribed width of the slanted belt layer to make 1 set, the slanted belt layer is in 2 sets.

[Claim 3] The pneumatic radial tire described in Claim 1 or 2 in which the cord of the belt layer of the circumferential direction is an organic fiber cord made of poly ethylene terephthalate, poly ethylene naphthalate or nylon.

[Claim 4] The pneumatic radial tire described in Claim 1, 2 or 3 in which the bulk modulus of the rubber which covers the slanted belt layer is more than 200 kgf/ mm^2.

[Detailed Description of the Invention]

[0001]
[Field of Application in Industry] This invention is related to the pneumatic radial tire having good uniformity, excellent cornering property and high speed durability. In particular, it is related to the tire for passenger cars and tire for small trucks.

[0002]
[Existing Technology] Currently, with the energy conservation being demanded vocally, the automobile field is investigating the savings of fuel consumption through weight reduction of and, with this, the demand of weight reduction for the tire is also rising every year. Particularly for the pneumatic tires for passenger cars, this trend is more visible. For this reason, the attempt to change the cord which is used in the tire from the steel cord to the organic fiber cord is being made. But, in the current state, this has not reached the level which satisfies the various performance of tires.

[0003] In the pneumatic tire, at the outer periphery of the crown section of carcass, the tire generally has the so called intersecting belts in which at least 2 layers of the slanted belt layers are laminated such that their steel cords intersect with each other.

[0004] However, this slanted belt layer is formed by cutting the rubber-coated fabric into the prescribed width in an oblique direction depending on the cord lay angle and, in this slanted belt layer, there is naturally generated the end section of the cut site of the cord. This tends to easily cause the generation of separation at the end section of the belt layer and so it is not desirable from the view point of durability.

[0005] In order not to generate the cut site of cord at the end section of the slanted belt layer, it is useful to form the slanted belt layer by having the belt body, which was prepared by rubber-coating of one or a plural number of cord, placed continuously in the zigzag form and placing the bending section of this belt body of zigzag form at the position of the ends of the slanted belt layer in the width direction. This concept was disclosed in Kokai Utility Model No. 96259 - 1973, Kokai JP No. 274904 - 1992 and Kokai JP No. 319017 - 1993.

[0006]
[The Problem Which the Invention Intends to Solve] The tires which are described in these publications do not have the cord cut section at the end section of the slanted belt layers. However, as shown in Fig. 3, for example, the step difference 11 of straight line shape (indicated by the thick line) is generated naturally ; in addition, depending on the method of winding, the step difference 12 of zigzag shape is also generated in some cases. The step difference 12 of zigzag shape is generated by positioning the belt body to intersect and overlap alternately ; this results in the structure where the cords constrain each other and so it has the advantage of improving the shear rigidity of the belt. But the step difference 11 of the straight line shape does not have this advantage and, rather, it has the large shortcoming of worsening the tire uniformity. This is a fatal shortcoming for the radial tire and, therefore, there was the need for developing the means of reducing the step difference 11 of straight line shape. Also, as for the cord of the slanted belt layer, it is desirable to use the organic fiber cord from the view point of lighter weight. However, the literature which disclosed the clear technology of applying organic fiber cord as the cord of the said slanted belt layer could not be found.

[0007] Thereupon, the objective of this invention is to provide the pneumatic tire, particularly the tires for passenger cars and small trucks, having good uniformity, excellent cornering property and high speed durability by using organic fiber cord made of poly ethylene naphthalate as the cord of the slanted belt layer and optimizing the twist structure, twist factor, tangent loss and cord diameter of the organic fiber cord.

[0008]
[The Means for Solving the Problem] To achieve the above described objective, this invention is

a pneumatic radial tire which is characterized by that,

in the pneumatic radial tire which is constructed by positioning in sequence the slanted belt layer, the belt layer in the circumferential direction and the tread at the outer periphery of the crown section of the carcass which forms a toroid shape mounted between at least a pair of bead cores,

the slanted belt layer is formed by having the belt body made by covering one or a plural number of cords with rubber placed continuously in a zigzag form in the direction of tire circumference and also by positioning the bending section of the belt body of this zigzag positioning at the end position of the width direction of the slanted belt layer, and

the cord of the slanted belt layer is the organic fiber cord consisting of poly ethylene naphthalate having double twisting structure and, if the twist number of this cord is denoted by T (times/ 10 cm), the total denier by D_T, and the specific gravity by ρ, the factor N_t which is expressed by the equation : $N_t = T \times (0.139 \times D_T / 2 \times 1/ \rho)^{1/2} \times 10^{-3}$ is in the range of 0.10 ~ 0.50 and the tangent loss tan δ is in the range of below 0.3 under the condition of initial tension 1 kgf/ end, strain amplitude 0.1 %, frequency 20 Hz and atmosphere temperature 25 deg C and the cord diameter is in the range of below 0.85 mm;

the belt layer in the circumferential direction consists of at least one layer and it is positioned on the slanted belt layer and the cord is wound in the spiral shape to arrange substantially in parallel to the tire's equatorial plane.

[0009] Also, it is preferred that,

when the belt shaped body covers the whole circumference of tire for the prescribed width of the slanted belt layer to make 1 set, the slanted belt layer is in 2 sets and that

the cord of the belt layer of the circumferential direction is an organic fiber cord made of poly ethylene terephthalate (PET), poly ethylene naphthalate (PEN) or nylon and that

the bulk modulus of the rubber which covers the slanted belt layer is more than 200 kgf/ mm^2.

[0010] Here, the double twist structure means the structure resulting from the process in which one piece of yarn or 2 pieces of yarn together is applied with the twisting (primary twist) and two of these are put together and the reverse twist is applied (final twist). Total denier D_T means the product of the denier of raw yarn and the number of yarns twisted together.

[0011] In Fig. 1 is shown the cross section in width direction of the typical pneumatic tire for passenger car which is in consideration under this invention. In the figure, 1 is the pneumatic tire, 2 is the bead core, 3 is the carcass, 4 is crown section of the carcass, 6 is the slanted belt layer, 7 is the circumferential direction belt layer, 9 is the end in the width direction of the slanted belt layer, 10 is the tread. In this pneumatic tire 1, the slanted belt layer 6, circumferential direction belt layer 7, and the tread 10 are placed in sequence on the outer periphery of the crown section 4 of the carcass 3 which forms toroid shape between at least a pair of bead cores 2.

[0012] The slanted belt layer 6 is formed, as shown in Fig. 3, by continuously placing the belt shaped body 8, which is made by the rubber coating of one or a plural number of cords, in zigzag form in the tire circumferential direction 5 and by placing the bending section 8a of the belt shaped body 8, which has this zigzag positioning, at the ends 9a, 9b of the width direction of the slanted belt layer. As shown in Fig. 4 or Fig. 5, for example, this slanted belt layer 6 is formed as follows: the belt shaped body 8 is wound from the end 9a or 9b at one side in the width direction toward the end 9b or 9a of the other side in the width direction and it is bent at this end 9b or 9a of the width direction (bending angle α) and, next, from the end 9b or 9a at the other side in the width direction, toward the ends 9a or 9b at one side in the width direction, it is wound and placed in the zigzag form. This forming is conducted repeatedly and, specifically, for N (integer) rotations of the tire, a total of M (integer) times of the bending is conducted alternately at the ends 9a, 9b in the width direction. In this, the circumferential pitch is determined to let the belt shaped body shift forward or backward such that the belt shaped body which was wound first and the belt shaped body which is wound next are positioned at a prescribed distance, to form the slanted belt layer 6. Fig. 5 shows the state in which, from the position 13 as the starting point, during the N rotation of the tire, a total of M bending is done at the ends 9a, 9b in the width direction of the slanted belt layer 6 and, after this, the belt shaped body arrived at the neighboring position 14 of the starting point 13. By this technique, it is possible to place the belt shaped body at the desired slanting angle without generating gap

between the neighboring belt shaped body. In the slanted belt layer 6 which is obtained by this technique, as shown in Fig. 3, the zigzag shaped step difference 12 is generated. Thus, in the slanted belt layer 6 shown in Fig. 3, the belt shaped body 8 overlaps by intersecting and, by this, the cords have the structure of constraining each other and, so, compared to the slanted belt layer shown in Fig. 4, the belt's shear rigidity can be improved.

[0013] Also, the cord of the slanted belt layer 6 is the organic fiber cord made of PEN and it has the double twist structure. The twist factor Nt of the cord of slanted belt layer 6 is in the range of 0.1 ~ 0.50. If it is less than 0.10, the cord scatters and so the workability is poor. Also in order to secure the rigidity of cord, it is necessary to be less than 0.50.

[0014] The tangent loss, tan δ, of the cord of slanted belt layer 6 is in the range of below 0.3 under the condition of initial tension 1 kgf/ cord, strain amplitude 0.1 %, frequency 20 Hz and atmospheric temperature 25 deg C. The organic fiber cord has a large work loss and generates heat easily and so it can generate heat and melt easily at high speed running, finally leading to the hazard of tire bursting. To prevent this, the tangent loss needs to be in the range below 0.3. In addition, as to the coating rubber of the slanted belt layer 6, it is preferred to have a bulk modulus of over 200 kgf/ mm2 when the local movement of the rubber needs to suppressed further.

[0015] Also, to make the straight line shaped step difference 11 of the slanted belt layer 6 smaller, the diameter of the cord of the slanted belt layer 6 is kept in the range of below 0.85.

[0016] As to the number of layers of the slanted belt layer 6, a smaller number is preferred for lighter weight in the case of passenger car tire; on the other hand, in the case of small truck tires, tire inner pressure is approximately 2 times that of the passenger car tires in many cases and so, from the view point of strength maintenance, as shown in Fig. 2, the slanted belt layer is made in 2 sets preferably. But, in any case, the number of sets of slanted belt layer can be increased as needed. Also, as for the slanted angle of the cord of the slanted belt layer 6, it is in the range of 15 deg ~ 45 deg with respect to the equatorial plane of the tire ; for ease of production, it is preferably in the range of 15 deg ~ 30 deg.

[17]
[0017] The circumferential direction belt layer 7 consists of at least 1 layer; it is positioned over the slanted belt

layer 6 and the cord is wound in spiral form is arranged substantially in parallel to the tire equatorial plane.

[0018] As for the number of layers of the circumferential direction belt layer, 1 ~ 2 layer is preferred for lighter weight. Also, when there is the need of effectively suppressing the pressing-out of the crown center section at the high speed running, it is preferred to have 2 layers at the crown center section and 1 layer at the remaining crown section. When there is the need of effectively suppressing the belt edge separation, it is preferred to have 2 layers of the circumferential direction belt layer 7 and 1 layer of it in the remaining crown section. The selection of these can be made suitably depending on the application. As for the cord of the circumferential belt layer 7, it is preferred to use the organic fiber cord made of PET, PEN or nylon having excellent compressive fatigue characteristics. Further, as to the tangent loss tan δ of the said cord, less than 0.3 is preferred for the same reason as with the cord of the slanted belt layer.

[0019] As for the carcass cord, the organic fiber cord such as PET is used for the ply cord and this cord is positioned preferably at an angle of 70 ~ 90 deg relative to the tire equatorial plane.

[0020]
[Action] In the pneumatic tires of this invention, the circumferential direction belt layer 7 which does not have the step difference is placed over the slanted belt layer 6 and, by making the diameter of the slanted belt layer 6 small, the step difference of the slanted belt layer 6 is also made most simple and small. Consequently, uniformity of tire improves.

[0021] Also, at the end sections 9a, 9b in the width direction of the slanted belt layer 6, the cut site of cord is not generated as in the existing slanted belt layer of sheet form and the occurrence of separation at the belt end section is few and, consequently, the high speed durability is improved. Further, by using the organic fiber cord made of PEN in the cord of the slanted belt layer 6, and particularly by keeping the twist factor of this organic fiber cord in the correct range, weight reduction of tire can be achieved and the rigidity of cord can be enhanced and this increases the cornering power and improves the cornering characteristics.

[0022] In addition, by keeping the tangent loss of the cord of slanted belt layer 6 below 0.3 under the prescribed condition, melting of the cord by the self heating of cord can be prevented. Also, particularly in the case of the small sized truck tires, the slanted belt layer 6 can be made in 2

sets and, by this, sufficient tire strength to stand the higher service pressure inside the tire can be obtained. If the bulk modulus of the coating rubber of the slanted belt layer 6 is too low, the said cord can move easily and local buckling of cord can occur easily, generating the danger of cord breaking. Also, by using the organic fiber cord made from PET, PEN, or nylon which has good compressive fatigue resistance in the cord of the circumferential direction belt layer 7, it is possible to suppress the compressive fracture which occurs with the belt buckling deformation which tends to occur during severe cornering.

[0023]
[Examples of Application] In the following, specific examples of the passenger car tires and small truck tires which follow this invention are explained by referring to the figures, respectively.

(1) Passenger car tire

The pneumatic tires which were used in Examples of Application 1 ~ 6 had the width direction cross section shown in Fig. 1. Tire size was 195/ 65R14. At the outer periphery of the crown section 4 of carcass 3 which forms the toroidal shape between a pair of bead cores 2, the slanted belt layer 6, the circumferential belt layer 7 and the tread 10 were placed in sequence. The slanted belt layer 6 and the circumferential direction belt layer 7 were in 1 set, respectively. For the cord of the slanted belt layer 6, Table 1 summarizes the material, twist structure, twist factor, tangent loss, cord angle, cord diameter and the presence or absence of the circumferential direction belt layer 7, the material and twist structure of its cord. Bulk modulus of the coating rubber of the slanted belt layer was 280 kgf/ mm2 in Examples of Application 1 ~ 5, 180 kgf/ mm2 in Example of Application 6. The slanted belt layer 6 had the planar shape as shown in Fig. 3 and, by following what is shown in Fig. 5, the forming was done for M=9 and N=4, i.e. the values which are close to a circumferential pitch of f = 9/4. The circumferential direction belt layer 7 was formed by arranging the cord at an angle of about 0 deg relative to the tire equatorial plane by spirally winding. Width of the circumferential belt layer 7 was 130 mm and the width of the slanted belt layer 6 was 140 mm.

[0024] [Table 1]

		A	B	C	D	E	F	G	H	I
		傾斜ベルト層						周方向ベルト層		
		コード材質	コード径 (mm)	コード角度 (°)	より構造	より係数	正接損失	配設	コード材質	より構造
EE1	従来例1	スチール	0.63	±22	1×5 ×0.23	-	-	なし	-	-
C1	比較例1	PEN	0.93	±22	3000d/2	0.50	0.18	なし	-	-
2	比較例2	PEN	0.80	±22	1500d/3	0.50	0.18	なし	-	-
3	比較例3	PEN	0.93	±22	3000d/2	0.50	0.18	あり	PET	1500d/2
4	比較例4	PEN	0.67	±22	1500d/2	0.07	0.35	あり	PET	1500d/2
5	比較例5	PEN	0.67	±22	1500d/2	0.58	0.35	あり	PET	1500d/2
6	比較例6	PEN	0.67	±22	1500d/2	0.50	0.35	あり	PET	1500d/2
7	比較例7	PEN	0.67	±22	1500d/2	0.30	0.35	あり	PET	1500d/2
E1	実施例1	PEN	0.80	±22	1500d/3	0.50	0.18	あり	PET	1500d/2
2	実施例2	PEN	0.67	±22	1500d/2	0.50	0.18	あり	PET	1500d/2
3	実施例3	PEN	0.67	±22	1500d/2	0.50	0.18	あり	ナイロン	1260d/2
4	実施例4	PEN	0.67	±22	1500d/2	0.30	0.30	あり	PET	1500d/2
5	実施例5	PEN	0.67	±22	1500d/2	0.30	0.18	あり	PET	1500d/2
6	実施例6	PEN	0.67	±22	1500d/2	0.30	0.18	あり	PEN	1500d/2

A ~ F. Slanted belt layer; A. Cord material; B. Cord diameter (mm); C. Cord angle (deg.); D. Twist structure; E. Twist factor; F. Tangent loss;
G ~ I. Circumferential direction belt layer; G. Installation; H. Cord material; I. Twist structure
EE1. Existing Example 1; C1. Comparative Example 1; E1. Example of Application 1
Column G.
EE1, C1, C2. None; Other cases: Yes.

[0025] The pneumatic tires which were used in Comparative Examples 1 and 2 did not have the circumferential direction belt layer. Also, the pneumatic tires which were used in Comparative Examples 3 - 7 had the same cross section of width direction shown Fig. 1 but at least one of the twist factor, tangent loss and cord diameter of the slanted belt layer was outside the proper range. Bulk modulus of the coating rubber of the slanted belt layer was 280 kgf/ mm2 in all cases.

[0026] In the pneumatic tire which was used in the existing example 1, there were the cross plied 2 layers of slanted belt layer 6 in which were arranged a plural number of steel cords of cord structure of 1 x 5 x 0.23 which extended at an angle of ± 22 deg relative to the tire equatorial plane 5. There was no circumferential direction belt layer 7.

[0027] (2) Tire for small sized truck

The pneumatic tires which were used in Examples of Application 7 ~ 9 had the width direction cross section shown in Fig. 2. Tire size was 195/ 85R16 12PR. At the outer periphery of the crown section 4 of carcass 3 which forms the toroidal shape between a pair of bead cores 2, the slanted belt layer 6, the circumferential belt layer 7 and the tread 10 were placed in sequence. The slanted belt layer 6 was in 2 sets and the circumferential direction belt layer 7 was in 1 set. For the cord of the slanted belt layer 6, Table 2 summarizes the material, twist structure, twist factor, tangent loss, cord angle, cord diameter and the presence or absence of the circumferential direction belt layer 7, the material and twist structure of its cord. Bulk modulus of the coating rubber of the slanted belt layer was 320 kgf/mm2 in all cases. The slanted belt layer 6 had the planar shape as shown in Fig. 3 and, by following what is shown in Fig. 5, the forming was done for M=9 and N=4, i.e. the values which are close to a circumferential pitch of f = 9/4. The circumferential direction belt layer 7 was formed by arranging the cord at an angle of about 0 deg relative to the tire equatorial plane by spirally winding. Width of the circumferential belt layer 7 was 100 mm and the width of the slanted belt layer 6 was 110 mm for upper layer and 125 mm for the lower layer.

[0028] [Table 2]

		A	B	C	D	E	F	G	H	I
		傾斜ベルト層						周方向ベルト層		
		コード材質	コード径 (mm)	コード角度 (°)	より構造	より係数	正接損失	配設	コード材質	より構造
EE1	従来例2	スチール	0.99	52	1×3×0.30	–	–	なし	–	–
				±17	1+6×0.28					
CE8	比較例8	PEN	0.80	±17	1500d/3	0.50	0.18	なし	–	–
9	比較例9	PEN	0.93	±17	3000d/2	0.40	0.18	あり	PET	1500d/2
10	比較例10	PEN	0.80	±17	1500d/3	0.67	0.35	あり	PET	1500d/2
11	比較例11	PEN	0.80	±17	1500d/3	0.30	0.35	あり	PET	1500d/2
E7	実施例7	PEN	0.80	±17	1500d/3	0.50	0.19	あり	PET	1500d/2
8	実施例8	PEN	0.80	±17	1500d/3	0.30	0.30	あり	PET	1500d/2
9	実施例9	PEN	0.80	±17	1500d/3	0.30	0.18	あり	PET	1500d/2

A ~ F. Slanted belt layer; A. Cord material; B. Cord diameter (mm); C. Cord angle (deg.); D. Twist structure; E. Twist factor; F. Tangent loss;
G ~ I. Circumferential direction belt layer; G. Installation; H. Cord material; I. Twist structure
EE1. Existing Example 1; C8. Comparative Example 8; E7. Example of Application 7
Column G.
EE1, C8. None; Other cases: Yes.

[0029] The pneumatic tire which was used in Comparative Examples 8 did not have the circumferential direction belt layer. Also, the pneumatic tires which were used in Comparative Examples 9 ~ 11 had the cross section of width direction shown Fig. 2 but at least one of the twist factor, tangent loss and cord diameter of the slanted belt layer was outside the proper range. Also, the bulk modulus of the coating rubber of the slanted belt layer was 320 kgf/ mm2 in all cases.

[0030] In the pneumatic tire which was used in the existing example 2, there were the total 3 layers of the slanted belt layer 6 which were positioned as follows: The one layer of the plural number of steel cords with a cord structure of 1 x 3 x 0.30 arranged by extending at an angle of 52 deg relative to the tire equatorial plane; The cross plied 2 layers of a plural number of steel cords of cord structure of 1 + t x 0.28 which extended at an angle of +- 17 deg relative to the tire equatorial plane 5. There was no circumferential direction belt layer 7.

[0031] (Testing method) For the above described various test tires, the tests for the evaluation of uniformity, cornering property and high speed durability were conducted separately for the passenger tires and the small sized truck tires. Also, for the passenger car tires, measurement of the tire weight was conducted together also.

[0032] (1) Uniformity test

The tire which was filled to the specification internal pressure was pushed against the drum under the specification load. The drum was rotated to let the tire rotate 60 times per minute. At this time, the unbalanced magnitude of the force in the radial direction, lateral direction and the forward - backward direction which were generated in the

tire was measured to evaluate the uniformity. Test results of the passenger car tire and small sized truck tires are shown in Table 3 and Table 4, respectively. In Table 3, the numerical value of uniformity is indicated in an index ratio with the existing example 1 taken as 100. In Table 4, the numerical value of uniformity is indicated in an index ratio with the existing example 2 taken as 100. In all cases, a smaller value is better.

[0033] (2) Cornering property test

Cornering property was evaluated by determining the cornering power. Measurement of cornering power was conducted as follows: On the drum of OD 3000 mm, the sample tire for which the pressure was adjusted to the maximum internal pressure specified in JATMA or JIS was set. The tire was loaded to the load which is specified in JATMA or JIS from the above said tire size and internal pressure. After this, at a speed of 30 km/ h, preliminary run was conducted for 30 minutes. In the loaded state, the pressure was readjusted to the above said internal pressure. Again the load at the preliminary run was applied. On the said drum, running at the same speed, the slip angle was applied to the maximum of 8 deg positively and negatively and continuously. Cornering force (CF) at each of the positive and negative angles was measured and the cornering power (CP value) was determined from the following equation.

$$CP\ (kgf/\ deg.) = [CF\ (1\ deg.) + CF\ (2\ deg.)/2 + CF\ (3\ deg.)/3 + CF\ (4\ deg)/4\ ]\ /\ 4$$

Test results for the passenger car tire and small truck tire are shown in Table 3 and 4, respectively. In Table 3, the numerical value of cornering property is indicated in an index ratio with the existing example 1 taken as 100. In Table 4, the numerical value of cornering property is indicated in an index ratio with the existing example 2 taken as 100. In all cases, a larger value is better.

[0034] (3) High speed durability test

High speed durability was tested by the step speed method in accordance with the test method of U.S. Specification FMVSS No. 10. Thus, the test was conducted with the speed increased every 30 minutes until a disorder occurred and the speed (km/ h) at the occurrence of disorder was measured and the evaluation was conducted by this. Test results of the passenger car tire and the small truck tire are shown in Table 3 and Table 4, respectively. In Table 3, the numerical value of high speed durability is indicated in an index ratio with the existing example 1 taken as 100. In Table 4, the numerical value of high speed durability is indicated in an index

ratio with the existing example 2 taken as 100. In all cases, a larger value is better. At this time, whether the cord melted or not was examined ; in the case of melting, [yes] is indicated and, in the case of no melting, [no] is indicated in Table 3 and Table 4, respectively.

[0035] [Table 3]

		A	B	C	D	E
		ユニフォミティ	コーナリング性	高速耐久性		タイヤ重量 (kg)
				指数	コード融解	
EE1	従来例1	100	100	100	なし	8.20
C1	比較例1	172	99	110	なし	7.62
2	比較例2	135	98	114	なし	7.62
3	比較例3	110	103	110	なし	7.91
4	比較例4	95	80	92	あり	7.89
5	比較例5	95	93	98	あり	7.89
6	比較例6	95	98	100	あり	7.89
7	比較例7	95	106	105	あり	7.89
E1	実施例1	98	101	114	なし	7.91
2	実施例2	95	98	119	なし	7.89
3	実施例3	95	100	119	なし	7.85
4	実施例4	96	108	110	なし	7.89
5	実施例5	95	108	123	なし	7.89
6	実施例6	96	106	123	なし	7.86

[0036] Table 4

		A	B	C	D
		ユニフォミティ	コーナリング性	高速耐久性	
				指数	コード融解
EE2	従来例2	100	100	100	なし
C8	比較例8	125	101	110	なし
9	比較例9	109	105	106	なし
10	比較例10	97	98	92	あり
11	比較例11	97	104	105	あり
E7	実施例7	96	101	114	なし
8	実施例8	98	104	105	なし
9	実施例9	96	104	114	なし

A. Uniformity; B. Cornering property; C ~ D. High speed durability; C. Index; D. Cord melting; E. Tire weight (kg); EE1. Existing Example 1; C1. Comparative Example 1; E1. Example of Application 1;

Column D.
C4 ~ C7, C10 ~ C11. Yes; Other cases. No;

[0037] In the result of Table 3, the passenger car tires of Examples of Application 1 ~ 6, in comparison to the passenger car tires of Existing Example 1, achieved large reduction of weight and, furthermore, overall performance of the uniformity, cornering property and high speed durability is better in comparison to the Existing Example 1. Also, in the test results of Table 4, the small size truck tires of Examples of Application 7 ~ 9, in comparison to the small size

truck tires of Existing Example 2, are better in terms of all of the uniformity, cornering property and high speed durability.

[0038]
[Effectiveness of the Invention] By this invention, it is possible to provide the pneumatic tires for passenger cars and the pneumatic tires for small trucks which have all of the good uniformity, excellent cornering property and high speed durability.

[Brief Description of the Figures]

[Fig. 1] shows the width direction cross section of the pneumatic tire for typical passenger car which is due to this invention.

[Fig. 2] shows the width direction cross section of the pneumatic tire for typical small truck which is due to this invention.

[Fig. 3] is a top view showing the slanted belt layer with a part removed to show the straight line- shaped step difference 11.

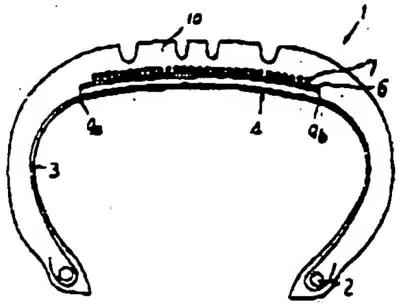
[Fig. 4] shows the method of forming the slanted belt layer.

[Fig. 5] shows the method of forming the slanted belt layer.

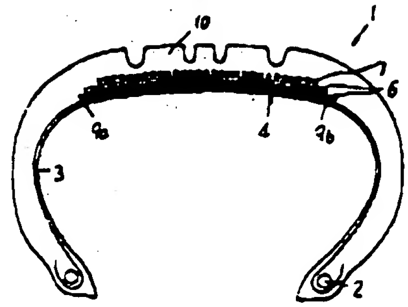
[Description of the Codes]

1 --- Pneumatic tire; 2. Bead core; 3 --- Carcass; 4 --- Crown section of the carcass; 5. Tire circumferential direction; 6. Slanted belt layer; 7. Circumferential direction belt layer; 8. Belt shaped body; 9. End in the width direction of the slanted belt layer; 10. Tread; 11. Straight line -shaped step difference; 12. Zigzag shaped step difference; 13. Starting point; 14. Neighboring position of the starting point 13; 15. Cord of the slanted belt layer 6.

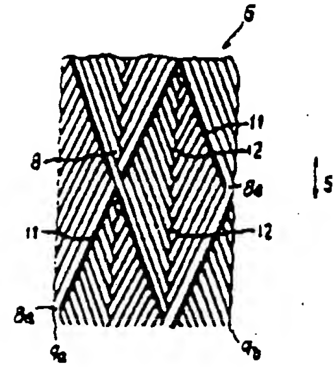
【図1】


10
1
7
6
9a
4
9b
3
2

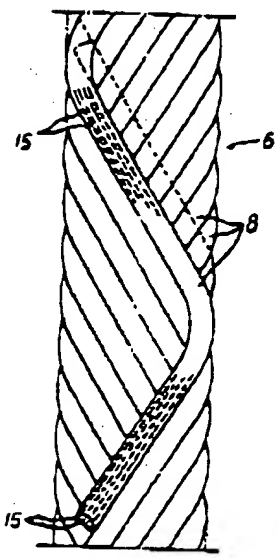
【図2】


10
1
7
6
9a
4
9b
3
2

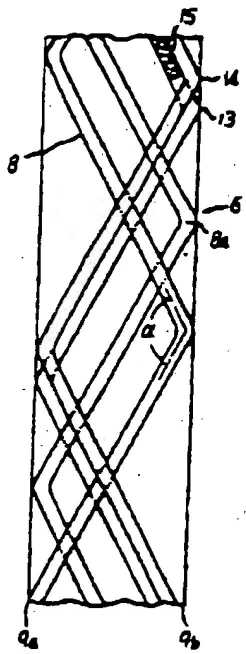
【図3】


6
11
12
8
8a
5
11
12
8a
9a
9b

【図4】


15
6
8
15

【図5】


15
14
13
8
6
8a
α
9a
9b